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6 January 1976

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LOW FREQUENCY PORTABLE BEACON OPERATING INSTRUCTIONS

Dennis W. Feller

NAVAL SURFACE WEAPONS CENTER
Contract N60921-74-C-0217,
Project CAPTOR

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APPLIED RESEARCH LABORATORIES
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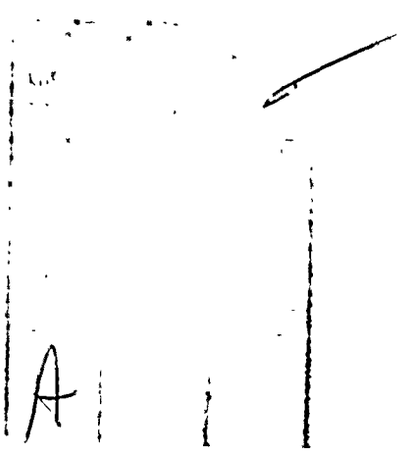
AUSTIN, TEXAS 78712

ABSTRACT

This report contains the operating instructions and circuit diagrams for the low frequency portable beacons being added to the Navigation, Tracking, and Communications (NTC) acoustic navigation subsystem at Fort Lauderdale, Florida. While designed for use at the Naval Surface Weapons Center Test Facility, the portable beacons combined with the Applied Research Laboratories' (ARL) range readers constitute a totally portable navigation system that could be used wherever water depths are not greater than 2000 ft.



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I. INTRODUCTION

Low frequency portable beacons were designed to be used in place of the regular NTC beacon or the high frequency portable beacon which transmits a 7.575 kHz continuous signal and a 6.944 kHz frequency shifted tone burst. As specified by the contract, the low frequency portable beacon was designed to operate at 2.424 kHz for the continuous tone and at 3.056 kHz for the tone burst which is transmitted once every 10 sec and lasts for 36 msec.

The continuous tone allows a sonar operator to passively track the beacon, thus providing a bearing. Using a synchronized range reader which is plugged into the sonar headset jack, the horizontal range to the beacon is determined from the time of arrival of the 3.056 kHz tone burst. From this bearing and range, the submarine course can be plotted for precise navigation through the acoustic test range.

The range reader, shown in Fig. 1, has a switch on the front panel which selects the input signal path. This switch should be set to 2500 when using low frequency beacons and to 7500 when using high frequency beacons. This switch, along with the submarine and beacon depth switches, must be properly set to obtain accurate range information from the range reader.

The source level for the continuous beacon tone is 55 dB re 1 μbar at 1 yd, while the source level for the tone burst is 65 dB re 1 μbar at 1 yd. The higher source level at the tone burst frequency allows better tone detection and thus a more accurate range.

The low frequency beacon system consists of 1) a beacon which contains all the signal generating electronics and the transducer,

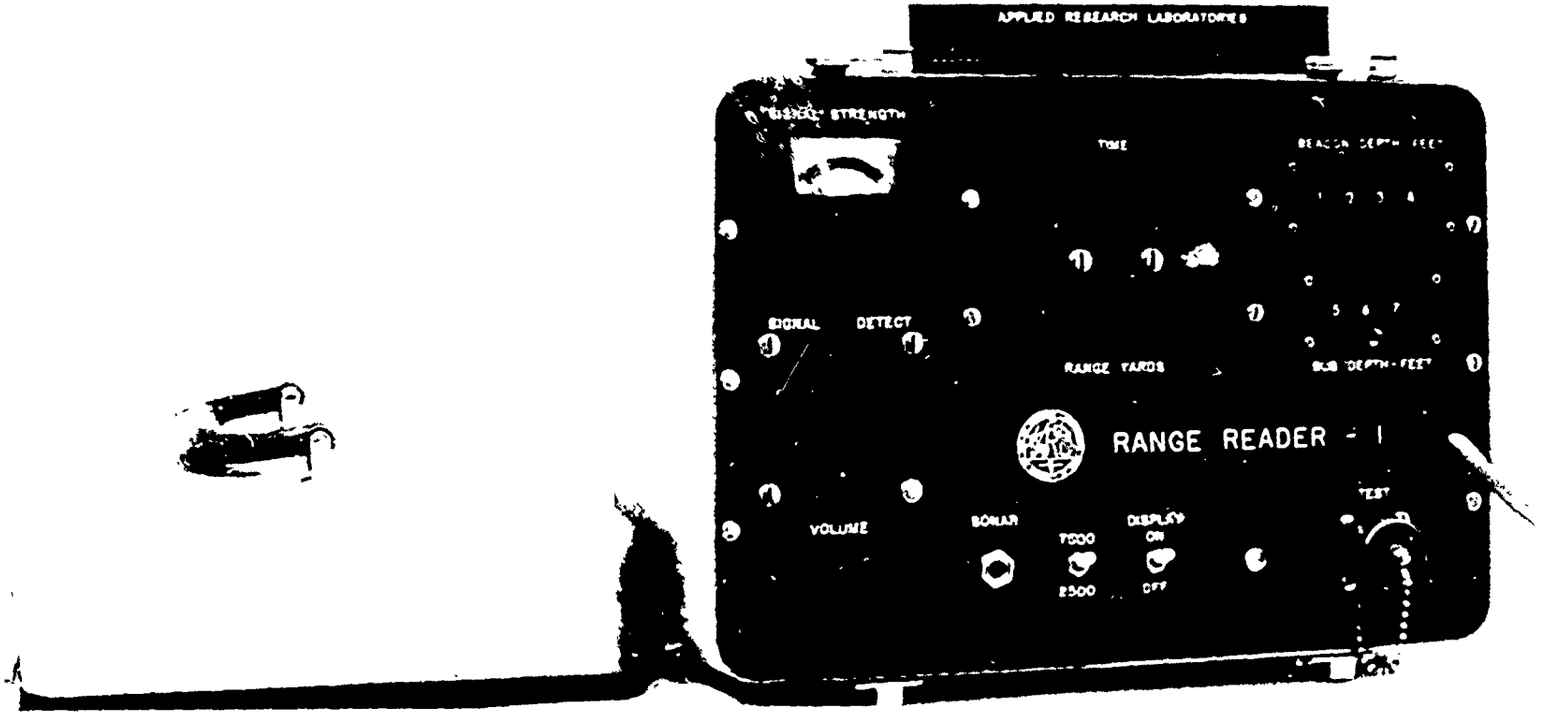

FIGURE 1
RANGE READER

2) a battery pack, and 3) a control unit which charges the battery and provides interconnections to the beacon.

When the battery pack is fully charged, it is capable of supplying power to the beacon for approximately six days. The beacon is provided with a battery cutoff circuit which switches off the battery power if the voltage drops below 15 V, thus preventing deep discharges which might permanently damage the battery. However, the portable beacon battery packs should be charging whenever the beacon is not in use and the beacons should be recovered as soon as possible after a ranging session so that the batteries are not damaged.

II. LOW FREQUENCY PORTABLE BEACON

A. Transducer

The transducer used for low frequency portable beacons (Figs. 2, 3, and 4) is larger than the one used in high frequency beacons, but is identical to the transducers used for the UQC transmitters on all the NTC Systems. Figure 5 shows a cross section of the low frequency transducer.

Even though the larger transducer has a lower frequency resonance, a double tuned circuit is required to efficiently produce the source levels required at both the continuous signal frequency and the tone burst frequency. Circuit diagrams of the double tuned circuit along with the other circuit diagrams are presented later in this report.

B. Oscillator and Frequency Adjustments

The oscillator used in these beacons is an Austron Sulzer Model No. 1115, 5 MHz oscillator designed specifically for underwater use. The power drain is about a factor of five lower than most oscillators which also have the 1×10^{-9}/24 h stability specification.

The reduced power drain is due to an oven temperature of 35°C, which is lower than the oven temperature of 50°C or more in most oscillators. However, this lower oven temperature does necessitate some caution during the planting operation. Since any temperature above 35°C (95°F) causes the oscillator frequency to drift out of the operating specifications, special care must be taken to prevent the beacon from heating to temperatures above 95°F while it is being transported to the planting site. Placing a tarp over the beacon or

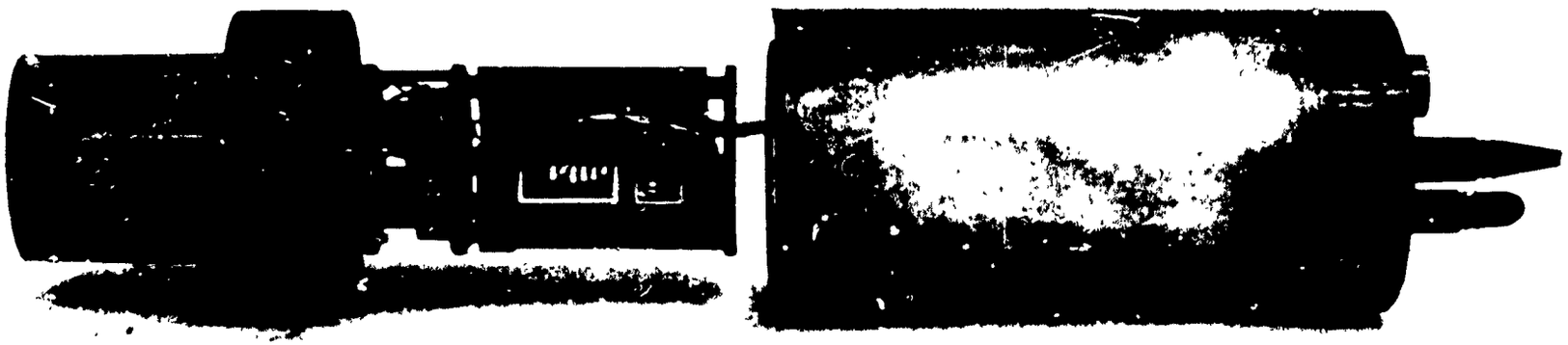

FIGURE 2
LOW FREQUENCY PORTABLE BEACON, TRANSDUCER,
ELECTRONICS, AND PRESSURE VESSEL – TOP VIEW

FIGURE 3
LOW FREQUENCY PC[illegible] BEACON, TRANSDUCER,
ELECTRONICS, AND PRESSURE VESSEL – SIDE VIEW

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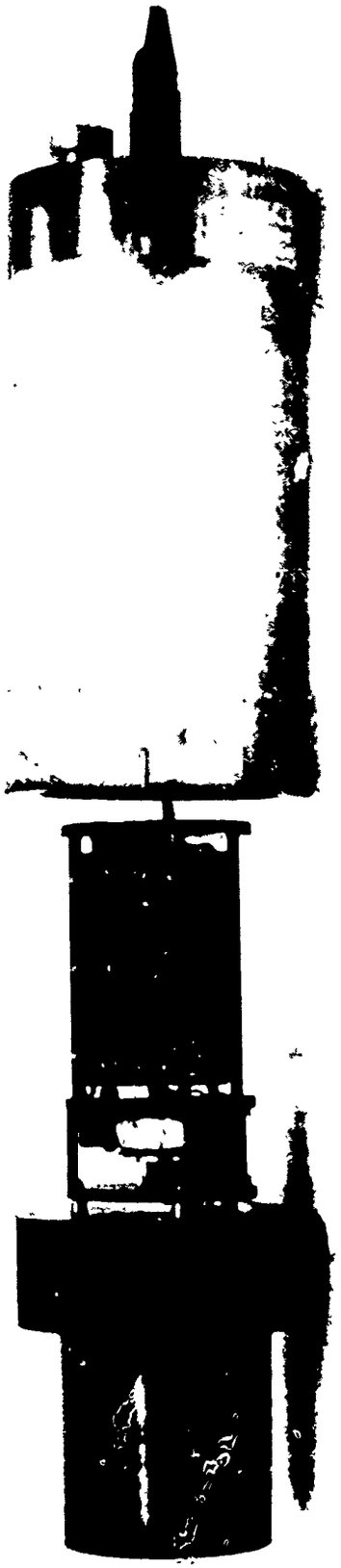

FIGURE 4
LOW FREQUENCY PORTABLE BEACON, TRANSDUCER
ELECTRONICS, AND PRESSURE VESSEL – BOTTOM VIEW

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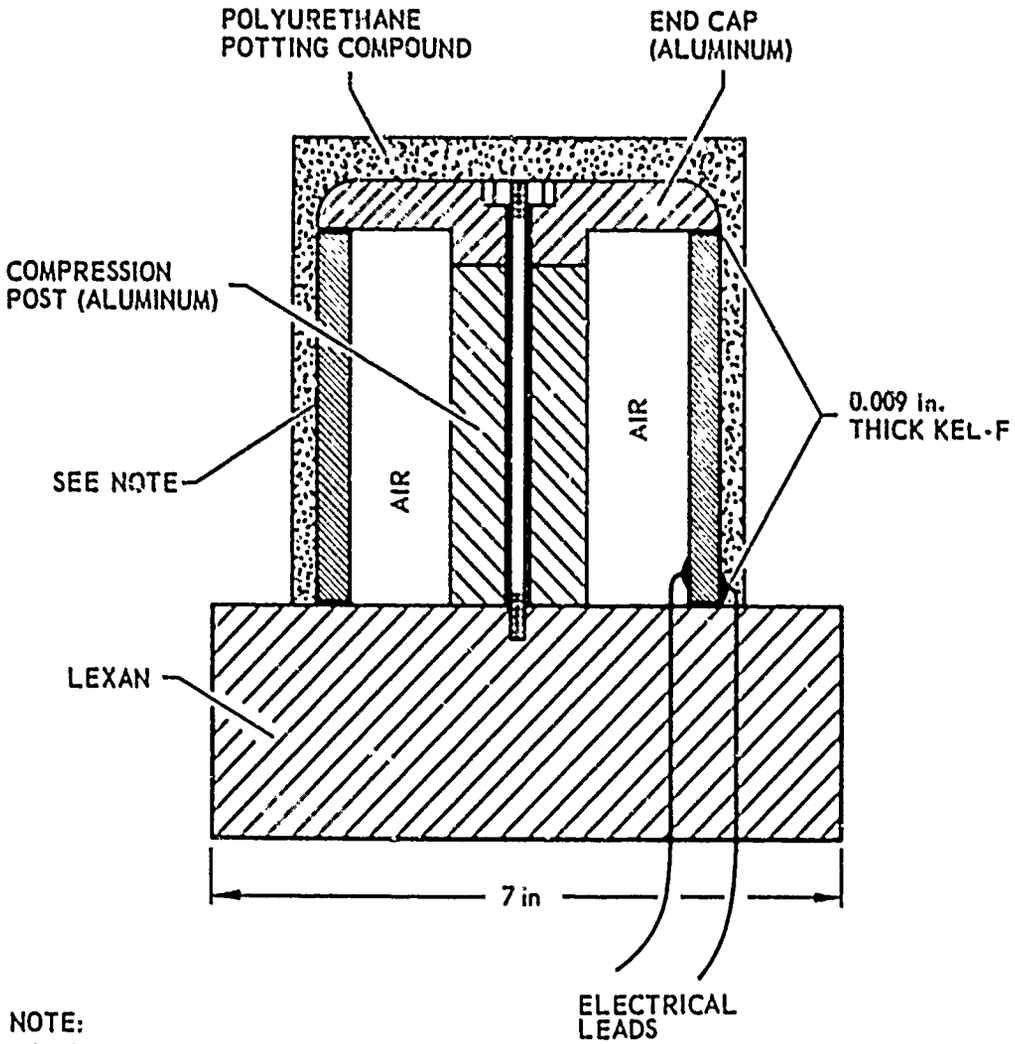

NOTE:
LEAD ZIRCONATE CERAMIC CYLINDER
4 in. LONG
0.3 in. WALL THICKNESS
DIAMETER TO RESONATE at 9.5 kHz
RADIALLY SILVERED AND POLARIZED

FIGURE 5
LOW FREQUENCY PORTABLE BEACON TRANSDUCER
CROSS SECTION

ARL - UT
AS-73-1067
DWF - DR
10 - 22 - 73

placing it in the shade will be sufficient to ensure a minimum of frequency and synchronization drift. Tests run at ARL indicated that if the beacon were left in a 125°F environment for a period of time extending to several hours, the range error rate would approach 8 yd/h. In other words, an extended exposure to high temperatures can cause a significant range error in the navigation system.

The 5 MHz oscillator frequency is divided down to 1 MHz which is provided as an output through the beacon control unit. To adjust this 1 MHz signal to match the 1 MHz reference frequency from the NTC clock, the potentiometer located on the printed circuit board inside the beacon pressure vessel provides electrical oscillator tuning. The beacon oscillator frequency should be adjusted after the oscillator is warmed up for several hours. When electrically tuning the oscillator, the frequency should be set so that the frequency error between the oscillator and the NTC clock is less than $\pm 1 \times 10^{-9}$. After the frequency is initially set, only occasional fine tuning should be required.

C. Saltwater Switch

The saltwater switch, which is the same as the switch used on the universal synced tracking pinger (USTP), consists of a Marsh Marine XSK-4-BCL connector and a modified RMS-4-FS plug. However, in addition to being part of the saltwater switch, the plug also switches battery power to the USTP. The only way to turn off battery power to the portable beacon is to disconnect the battery pack from the beacon.

Figure 6 shows a sketch of the saltwater switch. Connector pin 4 and the diode are not used in the portable beacons since their function is only to switch power in the USTP. The switches are identical so that they can be interchangeable in case one is misplaced. An arrow on the plug indicating the proper orientation of the switch should always be pointed toward the ON position stamped onto the pressure vessel. If the plug is in the OFF position, the transmitter will be inhibited, although the oscillator and countdown circuits will still receive power.

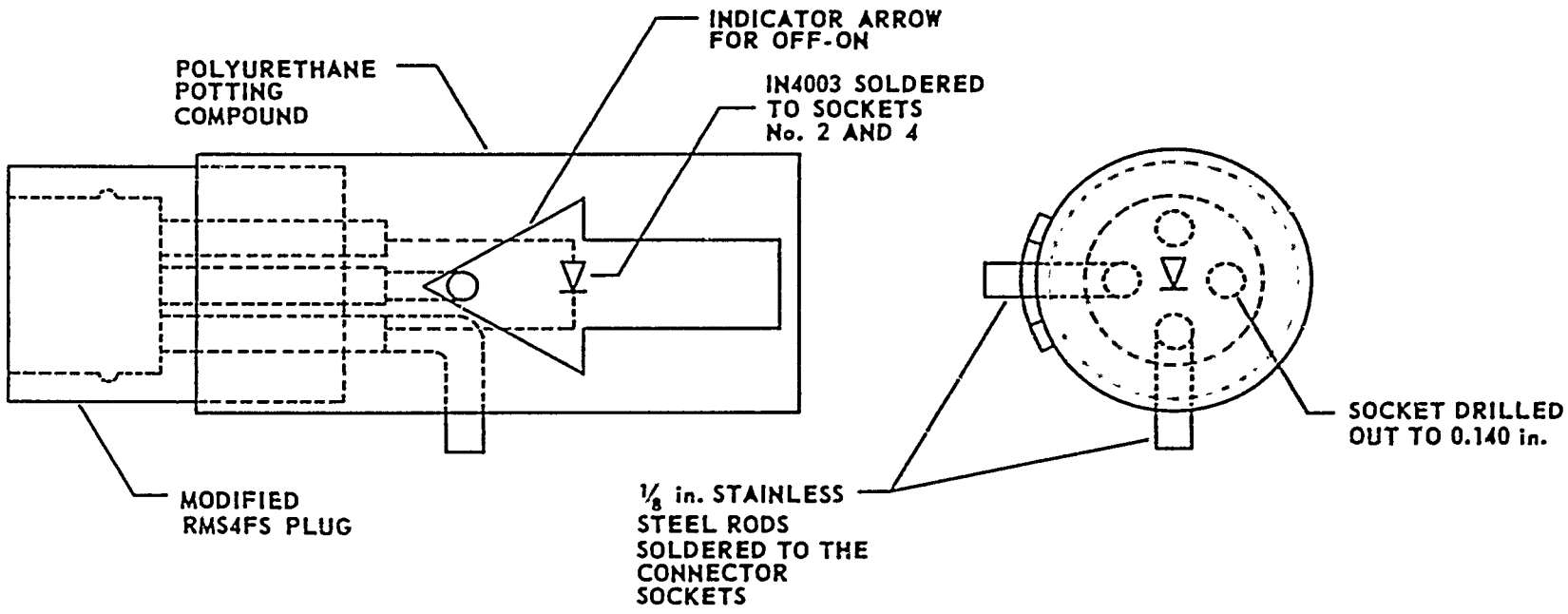

FIGURE 6
USTP ON-OFF SWITCH AND SALTWATER SWITCH
LOW FREQUENCY PORTABLE BEACON SALTWATER SWITCH

ARL - UT
AS-76-6
BRC - DR
1-13-76

III. BATTERY PACK

The battery packs are 24 V, 12 A h lead acid batteries. Although these batteries are rechargeable, deep discharges do permanently damage the cells. To help prevent deep discharges, the beacons have been provided with battery cutoff circuits which disconnect the battery from the beacon whenever the battery voltage drops below 15 V; battery power is restored whenever the voltage rises above 20 V. This hysteresis prevents the beacon from repeatedly turning on and off when the battery voltage nears 15 V.

Even though the battery is protected by the cutoff circuit, the beacon should be plugged into the beacon control unit as soon as possible after the ranging session so that the batteries get recharged and any unnecessary damage due to excessive discharge is prevented.

The pressure vessel is provided with a venting cap which releases the gases generated while the battery is charging or discharging. Whenever the battery is being charged, the venting cap must be loosened to allow the gases to escape. If the pressure vessel is not vented, the lid could pop off, causing a safety hazard. When preparing the beacon for planting, the venting cap must be tightened.

IV. BEACON CONTROL UNIT

The beacon control unit (Fig. 7) provides input and output connections in addition to a battery charger for two beacons.

A. ac Power

The beacon control unit requires 110 V, 60 cycle power. The switch located on the top left hand corner of the front panel controls the power to the control unit. A lamp inside the pushbutton switch illuminates when the power is turned on. If the lamp does not illuminate when the power is turned on, check the 1 A fuse located beside the power switch.

B. Battery Chargers

The battery charger puts out a charging current of 1 A until the battery voltage nears the maximum charging voltage of 29 V.

A switch on the front panel labeled CHARGER turns the charger on and off. The only time the charger should be turned off is when the beacon is being synced and disconnected from the control box. Turning the charger off reduces the possibility of a voltage spike triggering the synchronization circuit while the beacon is being disconnected.

A light emitting diode (LED) indicates when the battery is being charged. If the LED is not illuminated while the charger is turned on, check the 1 1/4 A fuse located inside the control unit beside the printed circuit board. Both chargers have a 1 1/4 A fuse.

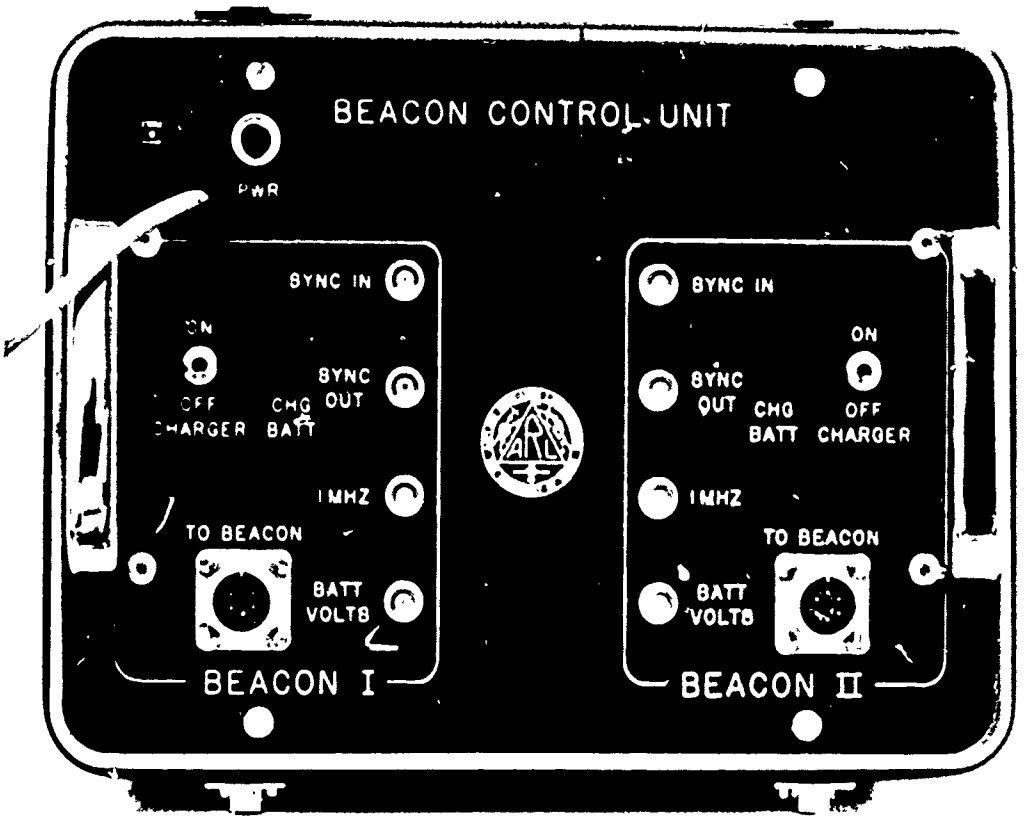

FIGURE 7
BEACON CONTROL UNIT

0217 – 18

C. Beacon Input and Output Connections

The two sets of four BNC connectors provide inputs to and outputs from the beacon. All of these connectors are wired directly to the 6-pin connector which is attached to the beacon by a cable. Therefore, the beacon control unit does not have to be turned on to sync the beacon or to monitor the sync output, the 1 MHz oscillator output, or the battery voltage.

1. Sync Input

The portable beacon can be synchronized by properly connecting the beacon to the control unit and then supplying the sync input BNC with a synchronization pulse from any other synchronized NTC equipment. As with all of the NTC equipment, the synchronization pulse occurs once every 10 sec and therefore proper synchronization may take as long as 10 sec.

After the beacon is synchronized and the cable between the control unit and the beacon is disconnected, the synchronization should be checked by placing a short across the saltwater switch and listening to ensure that the chirp occurs on an even 10 sec.

2. Sync Output

The sync output BNC allows the beacon synchronization to be checked while the beacon is still connected to the control unit. The sync output may be connected to the sync tester external sync input. The sync tester will then display the range error which is caused by a loss of synchronization or a drift in the oscillator frequency.

3. 1 MHz Output

The 1 MHz output allows the frequency of the beacon oscillator to be checked without opening the beacon pressure vessel. However,

if the oscillator frequency has drifted too much, the pressure vessel has to be opened for adjustment of the potentiometer.

4. Battery Voltage

The battery voltage should be checked before every ranging session to ensure that the battery is fully charged. To check the battery voltage, turn off the charger and connect a voltmeter to the BATT VOLTS BNC connector. The voltage should read about 26 V; if the voltage is below 23 V, at least one cell is bad and the battery must be replaced.

V. INTERCONNECTIONS

Figure 8 is a block diagram of the low frequency portable beacon system including interconnections between the beacon, the battery, and the control unit.

A. Beacon-Control Unit Interconnection

The cable connecting the beacon and the control unit is a custom built cable. The conductors carrying the sync input, sync output, and 1 MHz output are shielded so that the crosstalk between these conductors is minimized. The connector on the control unit is a MS3102A-14S-6P. The connector pin letters along with their functions are shown in Fig. 8.

The corresponding connector on the beacon is a Marsh Marine XSK-6-BCL. The connector pin numbers and their corresponding functions are also shown in Fig. 8.

B. Beacon-Battery Interconnection

The connectors on both the beacon and the battery pack are Marsh Marine XSK-3-BCL connectors. The cable assembly connecting the two units is a 10 ft B-5093 cable with RMS-3-FS connectors and plastic locking sleeves on both ends. The pin numbers and the corresponding functions are shown in the block diagram of Fig. 8.

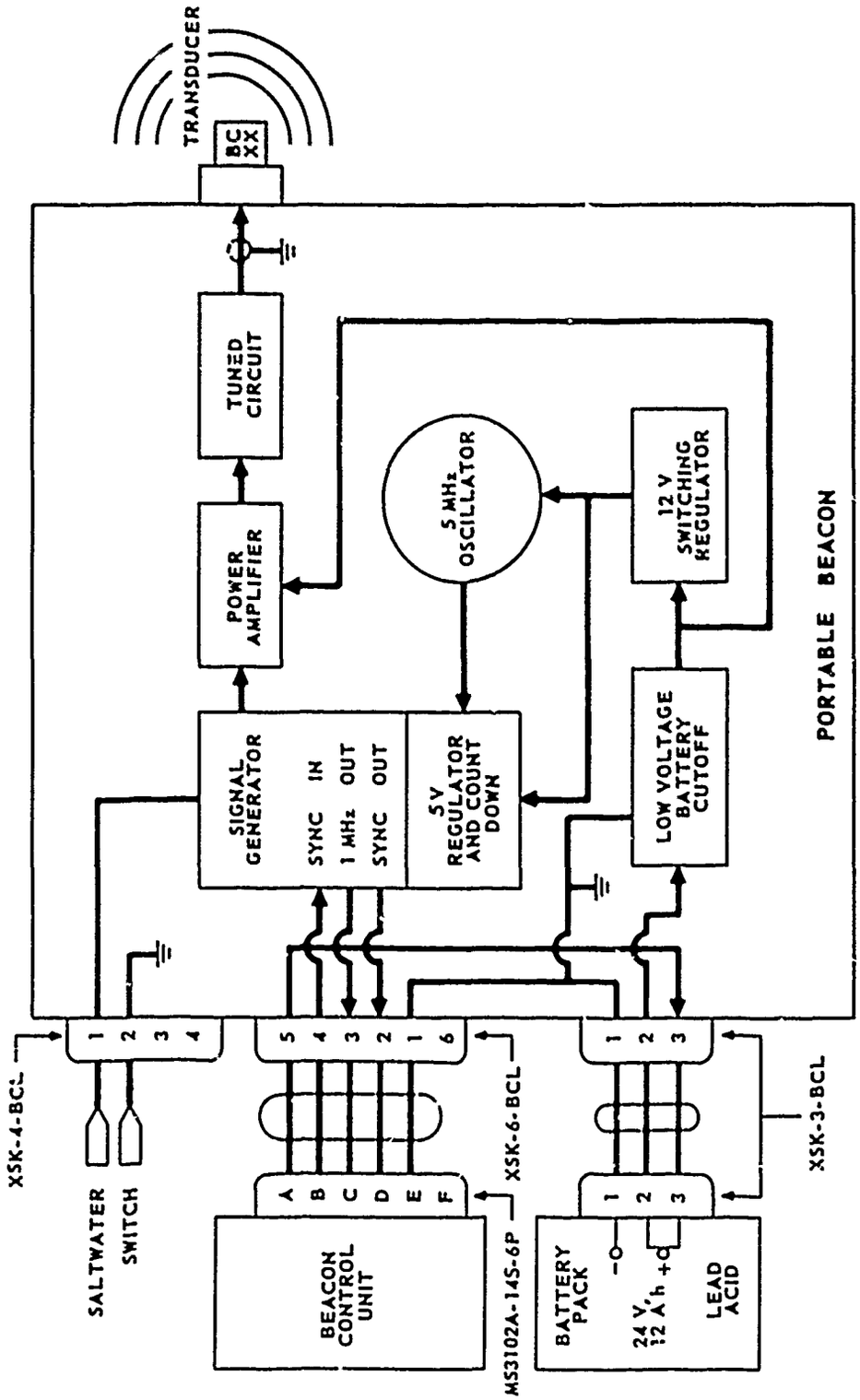

FIGURE 8
BLOCK DIAGRAM OF LOW FREQUENCY PORTABLE BEACON

ARL - UT
AS-75-1255
DWF - DR
9 - 22 - 75

VI. CIRCUIT DIAGRAMS

Figures 9, 10, and 11 show circuit diagrams for both the beacon and the control unit.

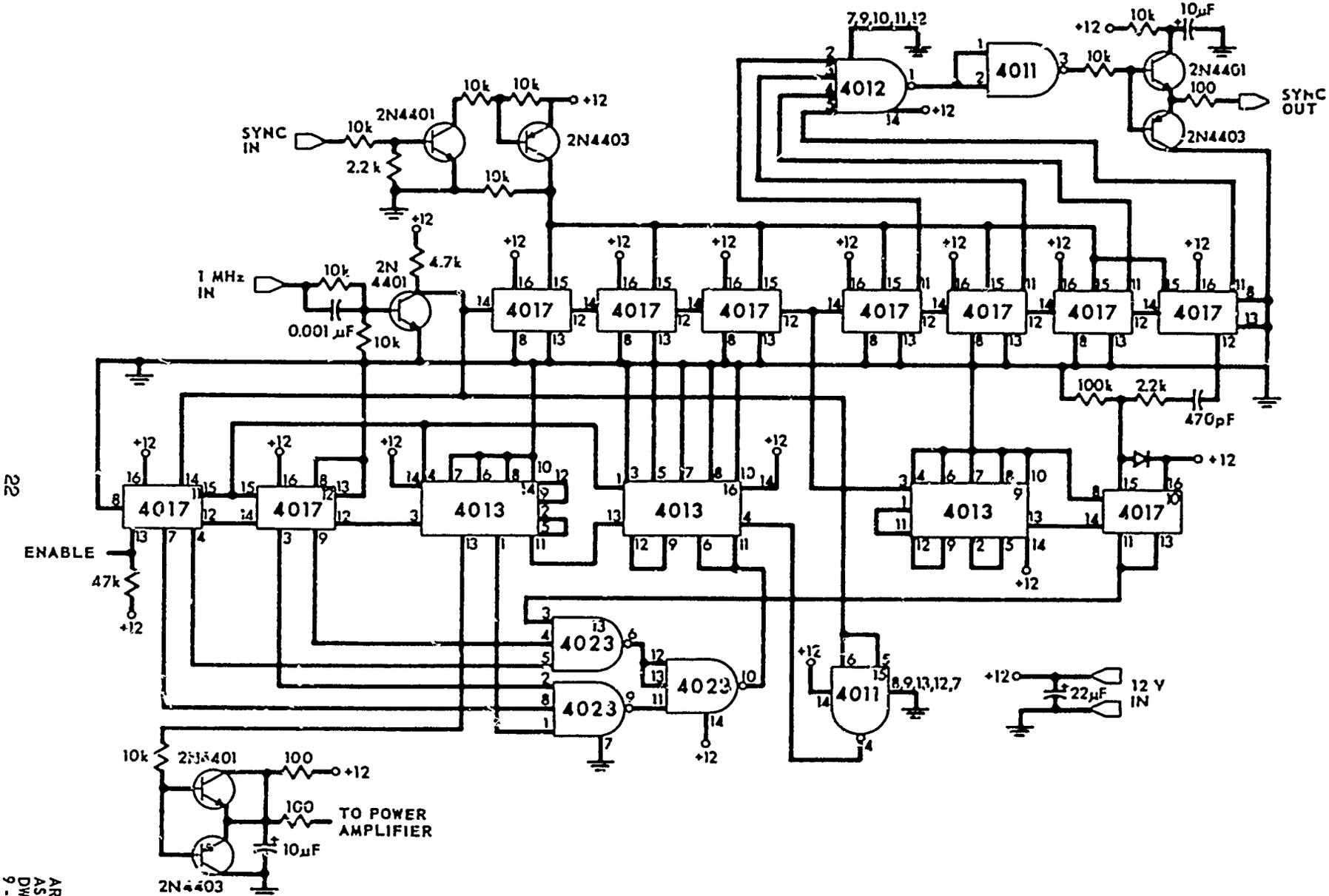

FIGURE 9
LOW FREQUENCY PORTABLE BEACON TIMING CONTROL CIRCUIT SCHEMATIC

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AS-75-1257
DWF - DR
9 - 22 - 75

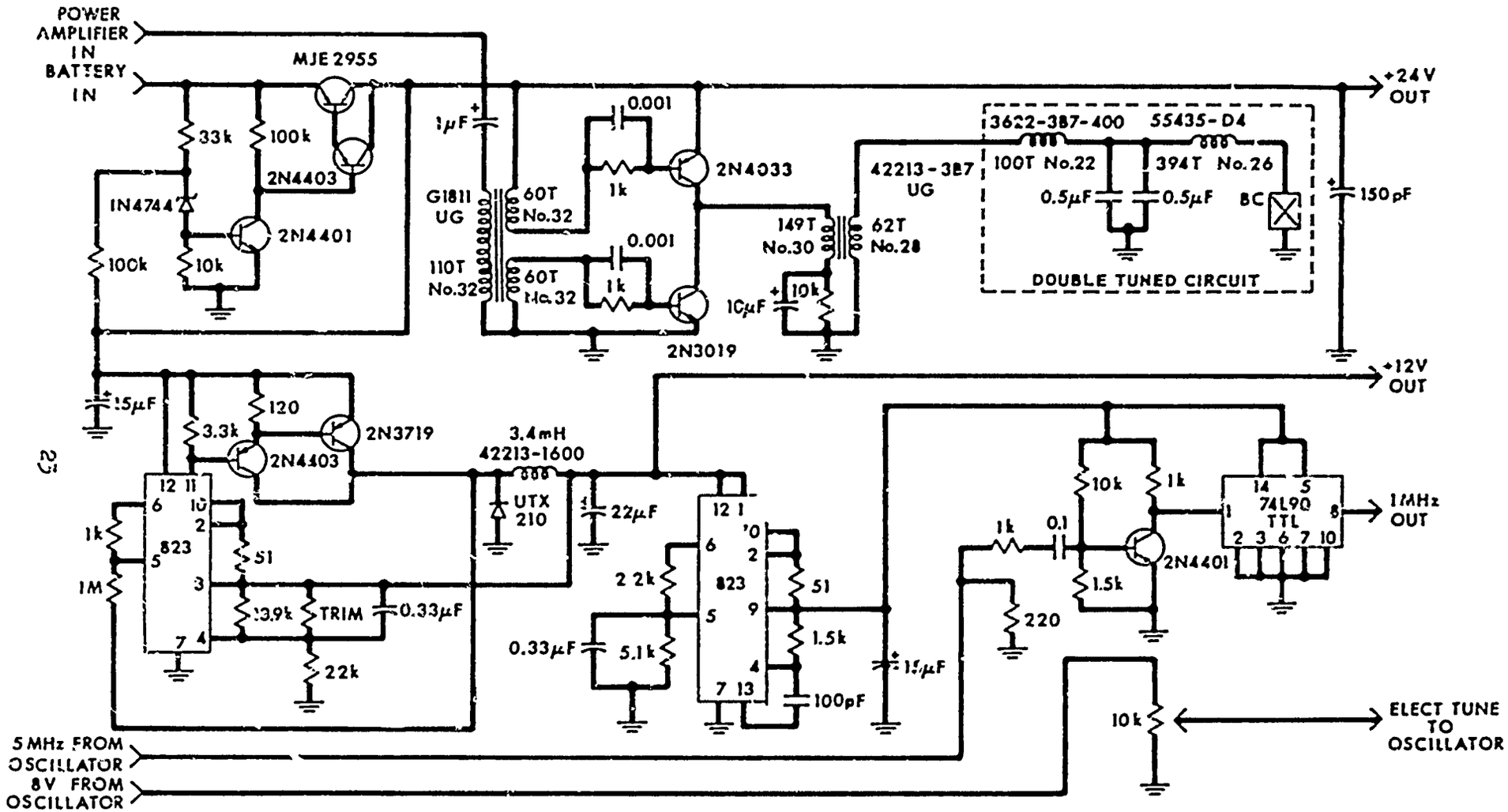

FIGURE 10
LOW FREQUENCY PORTABLE BEACON POWER AMPLIFIER
AND POWER SUPPLIES SCHEMATIC

ARL - UT
AS-75-1256
DWF - DR
9 - 22 - 75

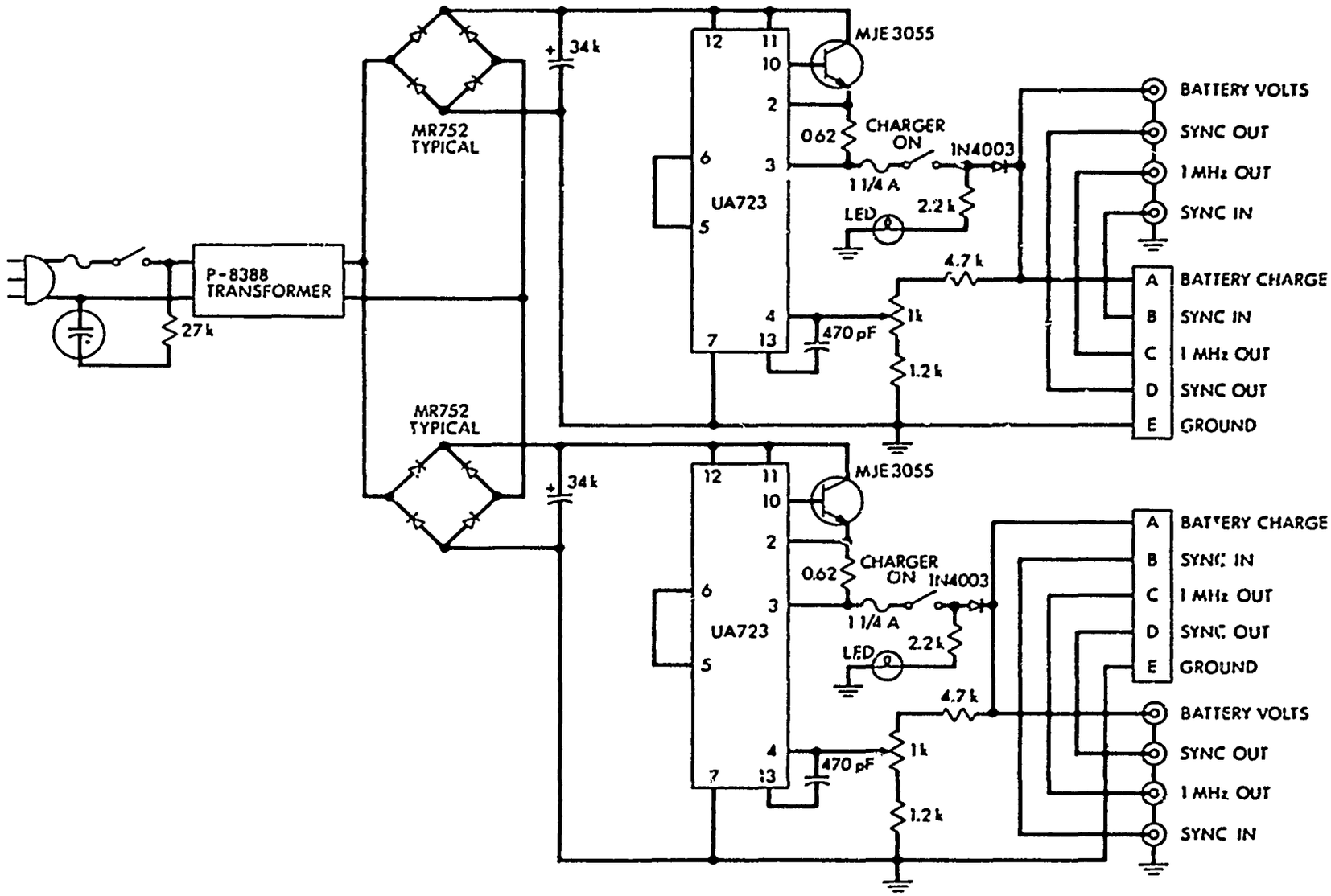

FIGURE 11
BEACON CONTROL UNIT CIRCUIT SCHEMATIC

ARL - UT
AS-73-676
WSO - DR
8 - 20 - 73
REV 1-15-76

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Acoustic range reader
Portable navigation system

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